Atmospheric Chemistry and Physics Discussions

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Comment on acp-2022-559

Anonymous Referee #1

Referee comment on "Gravity waves generated by the high graupel/hail loading through buoyancy oscillations in an overshooting hailstorm" by Xin Guo et al., Atmos. Chem. Phys. Discuss., https://doi.org/10.5194/acp-2022-559-RC1, 2022

General comments:

This paper reproduces the gravity waves generated by graupel/hail loading in a hailstorm, which were captured by radar observations, in a numerical model and examines their generation, propagation, and impact on the storm and stratosphere. The mechanism of gravity wave generation, in which the vertical equilibrium is disrupted by graupel/hail loading, looks new and interesting to the reviewer. Although the paper describes gravity waves based on temperature, pressure, and vertical wind perturbations, it is unclear which variations in the figures are corresponding to gravity waves for the most part, and many of them do not establish phase relationships among temperature, pressure, and vertical wind. In addition, four types of gravity waves (upward-propagating, downward-propagating, reflected, and trapped) are described, but the authors do not specify on what basis they made such judgments. The figures are also difficult to read, which makes it difficult to judge whether the authors' claims are correct or not. For these reasons, we consider it appropriate to reject this paper.

Specific comments:

- 1. Introduction
  There is too little information on past studies on convective GWs. For example, it should be described how convective GWs affect the stratosphere and/or the source storms more specifically. It should also be described how graupel/hail, the subject of this study, is or is not addressed in the past studies and what might change by considering graupel/hail.

- 2.1 Data
  Basic specifications of the radar such as station latitude/longitude, temporal/vertical resolutions, observation range in the vertical and horizontal, etc. are not described. There is no reference.

- 2.2 The model
  Is the method of giving the thermal bubble, its size and amplitude optimized? Are different values of each parameter tested?

- Description of GWs
  - L. 291-295, 296-298
  Why can you say that the pressure and temperature perturbations are due to downward-propagating GWs? I cannot catch which part of the figure is the downward-propagating GWs. Please show the t-z section.
  - L. 299-303
  The previous sentences state that pressure perturbation is due to GWs, but is the background pressure perturbations here different from that? If so, what is it due to?
  - L. 310-313
  As mentioned above, it is impossible to tell if it is downward-propagating without looking at the t-z section.
  - L. 320-328
  Why can you say that these temperature and vertical wind perturbations were enhanced by GWs?
  - L. 334-336
  I do not understand which part of the figure you are referring to as upward-propagating GWs.
  - L. 344-345
  Why do you think that it is due to the effect of upward-propagating GWs?
  - L. 347-348
  Is the wavelike structure of vertical velocity different from the above-mentioned GWs?
  - L. 363-367
  Why does continuous descending excite gravity waves, and why do GWs split storms?
  - L. 367-369
  In which part of the figures are GW amplitudes and wavelengths shown?
  - L. 387-389
  There does not appear to be any indication that GWs cause storms to split.
  - L. 398-408
  Pressure and temperature perturbations have different structures. They do not look like due to the same GW.
  - L. 434-443
  I do not see a gravity wave structure in the figure. If there is also energy and momentum transport, it should be shown in the figure.

- Figures
  - Which altitude range is the hodograph in Fig. 1?
  - The subscripts in Figs. 2 and 4 are missing.
  - What does "composite" mean in Fig. 2? Does it mean integrated in altitude? If not,

which altitude is drawn?
- The latitude of xz-section on the right side of Fig. 2 should be given by a line on the left side.
- The longitude ranges shown in Figs. $2a_2$-e_2 should be the same.
- The contour labels in Figs. 3-5 are too small to read.
- How were the environmental positive and negative temperatures obtained? Deviation from initial values?
- Why are the figures arranged differently in Figs. 4 and 5?

- L. 175-176, 183-184
  No southeastward extension is seen in Figs. $2b_1$ and $2c_1$.

- L. 178-181
  Please cite references that show a relationship between the magnitude of reflectivity and graupel/hail loading.

- L. 239-240
  "All modeled features are well consistent …" is an exaggeration. It is already split in the observation, but is not seen in Fig. 3c. Should be a correct description of what is consistent and what is not.

- L. 285
  "Perturbation" is perturbation from what? From the initial value? Explicitly state it.

- L. 306-310
  Why does a collapse of equilibrium cause a strong restoring force of buoyancy? Does it mean that the drag of the falling particles pulls on the surrounding air and the restoring force acts against it?

- L. 433-434
  I think that the cooled lower layer stabilize and do not rise.

Technical corrections:

- L. 81 and many places
  Please replay "stratospheric atmosphere" by "stratosphere".

- L. 143 and many places
  Please add "BST" after the time expression.

- L. 273
  Are graupel/hail mixing ratio and total hydrometeor mixing ratio the same or different? If they are the same, the same expression should be used.

- L. 319
  Which of vertical or horizontal does the wavelength mean?